Treatment of the gravity minewater discharge at Deerplay Mine, Burnley, UK

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Abstract: IMC Consulting Engineers were appointed by the UK Coal Authority to undertake a feasibility study into the remediation of a contaminated minewater discharge into the River Calder near Burnley in England. The estimated cost for the overall project, comprising civil, mechanical and electrical works is about 1.2 M ECU. The purpose of the project is to intercept the gravity minewater discharge of untreated minewater that is currently downgrading Black Clough and the River Calder.

The mine water discharges from old adits and collapses of ground on an upland moor at an average flow of 15 litres/sec. It contains a total iron of 20 mg/l and seriously downgrades the receiving stream and is visible in the River Calder up to 10 km downstream on occasions. A head of minewater of 25 metres has built up behind a blocked adit, which could give rise to a significant potential for downstream flooding and pollution should the seal become breached.

1 INTRODUCTION

Black Clough a steep sided stream rises on Deerplay Moor at a height of 409 m AOD and has a total length of 1.8 km., after about 0.6 km, minewater discharges from a series of old adits and/or collapses of ground on a steep upland moor in the valley of Black Clough (Figure 1).

The discharge normally affects the majority of the Black Clough to its confluence with the River Calder. During heavy precipitation the effect stretches over 10 Km downstream of the discharge due to erosion of accreted ochre from the receiving watercourse.

Downstream of its confluence with Black Clough the River Calder is able to sustain fish and has high biological diversity. Whilst Black Clough itself below the minewater discharge point is downgraded on biological grounds because of the absence of significant levels of flora and fauna because of the blanketing of the stream bed with ochre.

The purpose of the project is to intercept minewater from abandoned workings and thereby prevent the gravity minewater discharge of untreated minewater that is currently affecting Black Clough and the River Calder.

After outlining the history of the site and detailing the discharge location and minewater quality, the consideration for site selection will be discussed. Methods of treatment and interpretation of piezometer results will be considered. Finally the optimum solution to remediate the discharge will be described.

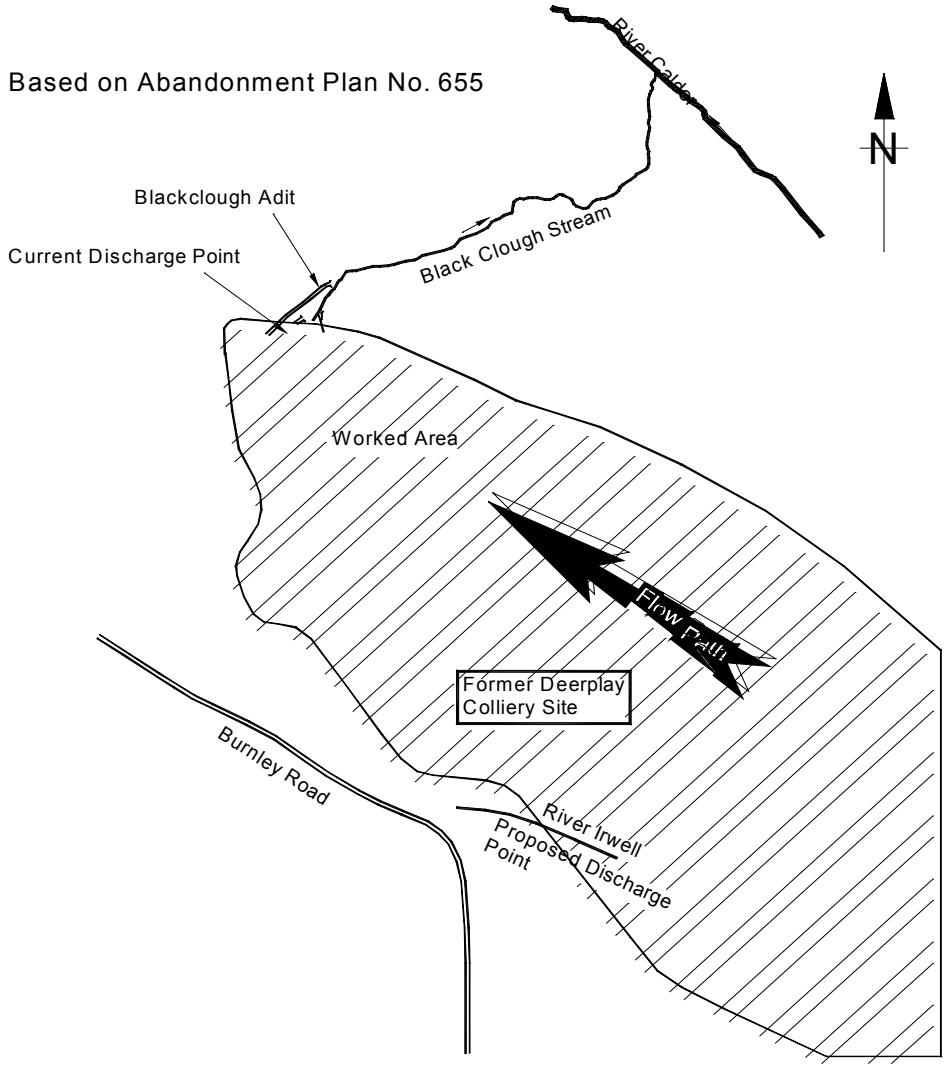

Figure 1

2 HISTORY

Coal Mining was undertaken from the mid 1920's and ceased in 1966 following the abandonment of Hill Top Colliery which resulted in the cessation of pumping. The outbreak of minewater from the Black Clough Adit was predicted and occurred in 1969. This initial discharge contained a total iron concentration of approximately 1000 mg/l and flows of 76 l/s (1000 g.p.m.). At present the total iron concentration is 20 mg/l with an average flow of 15 litres/sec.

Downstream abstractors were affected by this outburst and the visual and amenity values of the Black Clough and River Calder dramatically declined giving rise to public complaints and local political pressure to institute remedial action.

As a result of the outburst, and subsequent public pressure, a joint working party was set up in 1972 & 1974 to study the problem and suggest remedial works. The study groups concluded that a minewater treatment plant should be constructed. Studies were carried out at pilot plant scale, but unfortunately a full-scale plant was not constructed.

3 DISCHARGE LOCATION

In 1972 the discharge was via the Black Clough adit but over time this flow path became restricted (whether by a fall of ground or siltation with ochre is not known). The water has then overtime emerged from several adits upstream resulting in a total head above the original adit discharge point of 25 metres.

4 MINEWATER DISCHARGE QUALITY

Initially, the discharge is clear and colourless. However, the dissolved iron rapidly oxidises as the water cascades down the Black Clough changing from ferrous to ferric iron. The ochre accretion occurs down to its confluence with the River Calder. The Environment Agency requires a discharge quality of less than 2 mg/l total iron and a pH in the range of 6-9.

5 SITE SELECTION FOR THE TREATMENT SYSTEM

There are two possible locations for the treatment site which are detailed below:

5.1 Treatment Scheme at the Black Clough Adit

The re-establishment of the Black Clough Adit was considered as the main route for the minewater discharge. The main disadvantages of this was that the re-development of an underground roadway with a known head of water has a high risk, along with the environmental damage that could be caused during re-entry. Another risk considered was that the drift could become blocked in the future. The availability of land was also restricted.

5.2 Treatment Scheme on the Former Deerplay Colliery Site with Collection via a Surface Borehole into the Workings.

This would involve controlling the underground water level below the overspill to the Adit in the Deerplay Colliery mineworkings by pumping from a surface borehole sited near to the former Deerplay Colliery site.
The advantages of this method of minewater control are:

- It would reduce the risk of the minewater surfacing at other adits and surface boreholes.
- The risk of the blockage in the Black Clough Adit (or other lower adits) releasing large volumes of contaminated water, causing major downstream pollution and possibly flooding would be removed.
- Remediate Black Clough and the River Calder.
- There is land available for the construction of a treatment plant including sludge holding facilities. However provision of a site for the proposed surface pumping would need to be negotiated.
- Remediate the derelict site of the former Deerplay Colliery.

The disadvantages of this method of minewater control are:

- The minewater would have to be pumped and there would be continual operating costs (power and maintenance).
- The borehole would have to be sited (to control the water level below the overspill to the Adit) on the edge of Deerplay Moor, which may have an intrusive effect on the environment.
- The quality of the minewater pumped from the borehole might be worse than that currently free draining from the workings - the saturated area of mineworkings would reduce and the un-saturated area of workings would increase. However, any deterioration would probably be temporary.
- The Planning Authority expressed concern that such pumping may depress the groundwater level and thereby deplete the amount of water in nearby springs etc. reducing the flow in the moorland cloughs and drains.
- The Environment Agency would need to investigate the effect of losing this flow from Black Clough and the River Calder and conversely the effect of the additional flow in the River Irwell.
- There is a risk of drilling a borehole and not connecting to the minewater or not controlling the overflow because of the connectivity of water through the workings.

6 POSSIBLE METHODS OF TREATMENT OF THE MINEWATER

Three methods by which this minewater can be treated were considered:

- By neutralisation and settlement
- By wetland (reed bed)
- By aeration and settlement followed by tertiary wetland treatment.

The quality of the minewater discharge is such that there is no requirement to neutralise before further treatment. However, the quality of minewater may be changed by the effects of pumping.

A wetland only treatment was considered but it was felt by the local Planning Authority that the large area required within a moorland environment would not be acceptable.

The preferred option therefore was by simple aeration and settlement system followed by tertiary treatment on a reed bed. It would produce an effluent of quality acceptable to the Environment Agency and could be engineered to be robust, reliable and relatively easily maintained. It would not be visually intrusive on the environment of the surrounding area.

However before any method could be finalised investigation of the following factors need to be determined:

- the underground water regime and volume of water to be pumped.
- the quality of the water when pumped the effect on surface aquifers and the surface watercourses need to be determined.

It was considered that the best way to investigate the underground water regime would be to install piezometers at selected points and monitor over a period of time. However, to determine the water quality and effect to surface features a pump test is required.

7 PIEZOMETER INSTALLATION AND TEST RESULTS

From interpretation of the Abandoned Mine Plans and Reports the intended pattern of water flow through the workings was estimated as follows:

As part of an extended feasibility study a series of boreholes were drilled into defined areas of the mine workings and shallow measures. The information gained from the monitoring of the water levels in these boreholes has:

i. confirmed the heads of water in the various mine workings
ii. confirmed that the water in the mine workings lies independently and separate from the sub-surface aquifer.
iii. confirmed that the minewater, from the Lower and Upper Mountain Mine seams currently outfalling into Black Clough can be intercepted and controlled by pumping from a borehole from the surface into the Lower Mountain Mine seam workings of Deerplay Colliery

However, it should be noted that a small area of un-recorded mine workings in the Cannel Seam were intercepted by previous opencast operations and its is possible that other similar workings exist vertically above the Black Clough Adit. Following commencement of pumping operations, these workings (which are possibly not connected hydraulically to the Lower Mountain Mine) may continue to drain via the gravity discharge system but the volume of discharge is unlikely to have a significant effect on the receiving water course.

8 SYSTEM DESIGN

The abandoned mine plans along with the results of the piezometer results were used to determine a suitable location for a borehole scheme. During the installation of piezometer A1, a 1 metre void was intersected at the Lower Mountain (Union) Seam workings of Deerplay Colliery. This correlated with the abandonment plans and confirmed that a 2 metre wide roadway had been intersected. The site is 50 m to the North of the former Deerplay Colliery site.

Underground volumetric calculations were then undertaken to determine the borehole design, using pump size and required capacity. The volume of water contained behind the blockage was estimated in excess of 200 000 m^3.

In order to determine the effects of pumping on surface watercourses, aquifers and to determine the resulting quality of the pumped water, it was determined that a pump test should be undertaken. It was critical that the pumping borehole intersect the underground workings and that connectivity between workings is good enough to achieve the drawdown required to control the discharge point some 1.5 kilometres away.

In order to undertake a pump test, a phased scheme construction consisting of the pumping borehole along with temporary settlement to control discharge quality is required. A test duration of 10 weeks would achieve the drawdown required, pull minewater from the outflow position and effect the levels within the piezometers (which would be monitored by dataloggers).

During this test pump period the discharge quality and quantity will be monitored as will the draw down effects around the borehole. The test will also include a 2 week pre and 10 week post monitoring period of the water features in the area and the effect on the water levels within the piezometers, which have previously been, installed.

A temporary aeration and settlement system will initially treat the minewater. Back-up provisions to neutralise the minewater, using hydrated lime (or other suitable alkaline), may be required should the minewater be acidic when pumped. The phase 1 and 2 construction is shown on Figure 2 with expected discharge levels.

When information from the pump test has been obtained the design of the full treatment scheme can be undertaken. Subject to the water quality not changing the full treatment scheme will consist of a pumping borehole which will discharge at the rate of approximately 15 lit/sec into an aeration building followed by settlement of solids into twin lagoons. Tertiary treatment of the minewater using a wetland (consisting of Juncus due to the sites elevated position) will be undertaken prior to discharge to the River Irwell. The temporary lagoons used during the pump test will be converted into sludge drying beds, which will be used to store and de-water the sludge generated from the system.

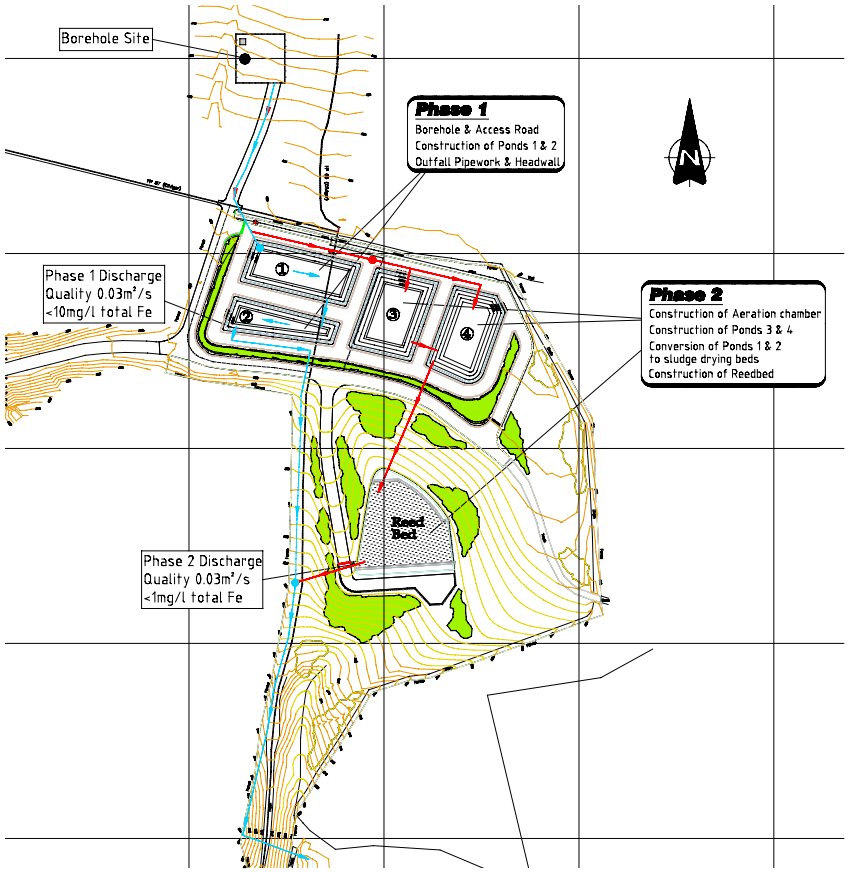

Figure 2

ACKNOWLEDGEMENTS

I would like to thank Adrian England and David Laine (IMC Consulting Engineers) for informative discussions on minewater treatment and The Coal Authority for their permission to reference the Deerplay Minewater Treatment Scheme.

Oczyszczanie odprowadzanych wód kopalnianych w Deeplay, Burnley, Wielka Brytania

Tracey M.Barnes

Streszczenie: Inżynierowie konsultanci z IMC otrzymali od Brytyjskich Władz Górniczych zlecenie wykonania studium możliwości poprawy jakości zanieczyszczonych wód kopalnianych odprowadzanych do rzeki Calder w

pobliżu Burnley w Anglii. Szacowany koszt całego projektu, włączając prace studialne, mechaniczne i elektryczne ocenia się na 1,2 miliona ECU. Celem projektu jest przechwycenie grawitacyjnego odpływu nieoczyszczonych wód kopalnianych, które obecnie obniżają jakość wód strumienia Black Clough i rzeki Calder.

Woda kopalniana wypływa ze średnią wydajnością 15 l/sek ze starych sztolni i zapadnięć gruntu na wrzosowiska. Zawiera 20 mg/l żelaza i poważnie zanieczyszcza strumień, do którego wpada. Jej wpływ zaznacza się również w rzece Calder w odległości 10 km w dół jej biegu. 25-metrowe podpiętrzenie wody kopalnianej utworzyło się za zablokowaną sztolnią, co może doprowadzić do zalania i zanieczyszczenia terenów położonych poniżej, jeśli uszczelnienie zostanie naruszone.